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(54) IMPROVEMENTS IN RECUPERATORS

(71) We, BRITISH STEEL CORPORATION, a Corporation incorporated and existing under the Iron & Steel Act 1967, of 33 Grosvenor Place, London, S.W.1, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to recuperators.

Metallic recuperators comprising tubes located in a waste gas duct for utilising the heat in waste gases from a furnace to preheat combustion air flowing through the tubes are well known. Such recuperators are used in conjunction with industrial furnaces such as soaking pits and slab reheating furnaces. Proposals have previously been made for recuperators having a partly ceramic construction, e.g. incorporating ceramic recuperator tubes. The advantages of recuperators of ceramic construction are that they can be used at higher operating temperatures and give longer lives than metallic recuperators. Their chief disadvantage is that they are prone to high leakage rates which result from the cracking of the ceramic materials and joints under expansion forces. Recuperator walls built of refractory bricks are particularly prone to this type of cracking, and even if a steel supporting shell is used there can be problems with the distortion of the shell under thermal stresses which will give rise to leakage. The problem is particularly acute where the recuperator tubes are sealed into header boxes fitted on the outside of the recuperator walls, since the wall can then not be supported by a steel shell if the recuperator is operating at high temperatures. Leakage can then occur from the relatively high pressure air stream in the header boxes into the relatively low pressure hot waste gas stream passing through the recuperator from the furnace.

It is an object of the invention to provide an improved construction of recuperator which reduces this leakage.

The invention provides a recuperator comprising a gas duct and including a plurality of generally horizontal tubes located at their ends in opposite walls of the duct, in which each opposite wall includes at least one monolithic refractory block having a plurality of holes extending through the thickness of the block, a respective tube end extending into each said hole and each such hole being of greater cross-section towards the outer side of the wall than at the duct defining inner side of the wall, and in which each said monolithic refractory block defines a section of duct wall which abuts another section of duct wall, the abutting joint being overlapped by a refractory member to prevent substantial leakage of gas through the wall of the duct at said joint.

Preferably the recuperator includes annular ceramic inserts fitted into the block so that the holes extend through the inserts.

It is preferred that the holes in the block are circular and the diameter of the holes at the outer side of the wall is greater than that at the inner side of the wall.

It is also preferred that at least part of the bore of each hole is tapered.

Preferably the tubes are ceramic.

It may be preferred that the abutting surfaces of the refractory block and an adjacent section of the refractory wall have a tongue and groove joint formation to assist in the location of the block and section whereby to reduce leakage.

Specifically the recuperator may include two or more pairs of opposed monolithic refractory blocks, each opposed pair being mounted one upon the other, and corresponding tubes located at each of their ends in opposed blocks, the arrangement forming a vertical set. All the tubes in any one pass of the recuperator may be located in one such vertical set. One pass of the recuperator is defined as a section of the recuperator across which all the gas to be heated in the recuperator passes once. There are usually several passes in a recuperator, thus enabling the gas to be heated to cross

the recuperator several times thereby increasing the temperature of the gas to be heated in several steps. The last pass is normally at the hotter end of the recuperator, i.e. adjacent the end of the recuperator where the waste gas from the furnace enters. By locating all the tubes in any one pass of the recuperator in one vertical set, the number of joints in the wall of the recuperator can be reduced, and any leakage can thereby be minimised.

The recuperator may include compressible annular seals surrounding the outer circumferential surface of the end of each tube, and means for maintaining the seals in a compressed state, recesses being provided in the sides of the holes in the blocks which cooperatively engage and hold the means for maintaining the seals in a compressed state.

Projecting means formed as part of each block and extending into the holes in the blocks may be provided for centrally locating the tubes within the holes.

In the accompanying drawings, figure 1 shows a plan view in section of part of a recuperator being one embodiment of the present invention, and figure 2 shows a cross section on line II II of figure 1.

A number of parallel ceramic tubes 10 are mounted across the duct 50 which carries hot waste gases from a furnace (not shown). The tubes 10 are located at their ends in respective monolithic refractory blocks 11 and 12. Each block 11 and 12 forms a section of the continuous wall of the duct 50, adjacent refractory sections to block 11 being identified as 13 and 14, and adjacent refractory sections to block 12 being identified as 15 and 16 respectively. A further pair of opposed monolithic blocks positioned further along the duct can be seen partly at 17 and 18, adjacent sections 14 and 16 respectively. A further set of tubes 10 extend between monolithic blocks 17 and 18 but these are not shown. The joints between abutting sections of the wall of the duct 50 have tongues and grooves which assist in location of sections of the wall and also minimise leakage into the duct 50. Each abutting joint is overlapped on the outside of the wall by either a refractory block 19, such as that overlapping the joint between block 12 and section 16, or by the end of a refractory wall 20 such as that shown overlapping the joint between block 12 and section 15. The joint between block 11 and section 13 is similarly overlapped by the end of a refractory wall 21 and the joint between block 11 and section 14 by the end of a refractory wall 22.

The tubes 10 are made of silicon carbide which is a heat-conducting ceramic material. Air to be heated in the recuperator is passed through the tubes 10 thereby enabling heat from the waste gas in duct 50 to be transmitted to the air. There are eight tubes 10 in two rows of four located in holes in the pair of opposite wall blocks 11 and 12. There are four pairs of similar wall blocks 11 and 12. There are four pairs of similar wall blocks positioned vertically above one another as seen in figure 2, so that there are in total thirty-two tubes in any one pass of the recuperator. The horizontal points between each block are tongued and grooved for purposes of location. Satisfactory sealing is generally obtained between the blocks by the action of gravitational force pressing each block tightly onto the other. Refractory fibre layers between the blocks can be used if sealing is unsatisfactory due to uneven surfaces in the joints.

The refractory wall 20 forms part of the wall of a header box 51 which serves to take the air from a previous set of tubes located between blocks 17 and 18 in which the air has already been heated, and supply it to the set of tubes 10 located between blocks 11 and 12.

The refractory walls 21 and 22 define a second header box 52 which serves to collect heated air leaving the tubes 10. The air in the tubes is under pressure and flows in the direction shown by the arrows marked within the tubes 10 in figure 1. The second header box 52 is connected to an outlet (not shown) which conducts the hot air to the process plant in which it is to be used.

The recuperator is supported by steel beams 23 adjacent wall section 16 and beams 24, 25, and 26 adjacent sections 15, 13, and 14 respectively. Beams 23 are surrounded by hot refractory structures and therefore require cooling. This is provided by a pipe 27 through which cooling air is discharged.

Each tube 10 is located in a hole in the monolithic refractory blocks 11 and 12. Each block has a number of annular inserts 30 which are fitted into the blocks so the holes in the blocks extend through the inserts 30. Each insert 30 has a recess 32 on its inner face which cooperatively engages a protrusion 33 on an annular single-piece ceramic locking ring 34 which serves to maintain compressible annular seals 60 surrounding the tube ends in a compressed state.

Projections (not shown) extend into each of the holes from the block for centrally locating the tubes within the holes. These projections are cast into the block when it is made.

An alternative embodiment of the invention does not include inserts fitted into the blocks, but has the tubes located into tapering holes which are cast into the monolithic refractory block.

Having regard to Section 9 of the Patents

Act 1949 attention is drawn to the claims of our Patent Application 20998/74 (Serial No. 1,504,703).

WHAT WE CLAIM IS:—

1. A recuperator comprising a gas duct and including a plurality of generally horizontal tubes located at their ends in opposite walls of the duct, in which each opposite wall includes at least one monolithic refractory block having a plurality of holes extending through the thickness of the block, a respective tube end extending into each said hole and each such hole being of greater cross-section towards the outer side of the wall than at the duct defining inner side of the wall, and in which each said monolithic refractory block defines a section of duct wall which abuts another section of duct wall, the abutting joint being overlapped by a refractory member to prevent substantial leakage of gas through the wall of the duct at said joint.

2. A recuperator as claimed in Claim 1 including annular ceramic inserts fitted into the block so that the holes extend through the inserts.

3. A recuperator as claimed in Claim 1 or Claim 2 in which the holes in the block are circular and the diameter of the holes at the outer side of the wall is greater than that at the inner side of the wall.

4. A recuperator as claimed in any preceding claim in which at least part of the bore of each hole is tapered.

5. A recuperator as claimed in any preceding claim in which the tubes are ceramic.

6. A recuperator as claimed in any preceding claim in which the abutting surfaces of the refractory block and an adjacent section of the refractory wall have a tongue and groove joint formation to assist in the location of the block and section whereby to reduce leakage.

7. A recuperator as claimed in any preceing claim including two or more pairs of opposed monolithic refractory blocks, each opposed pair being mounted one upon the other, and corresponding tubes located at each of their ends in opposed blocks, the arrangement forming a vertical set.

8. A recuperator as claimed in Claim 7 in which all the tubes in any one pass, as hereinbefore defined, of the recuperator are located in one vertical set.

9. A recuperator as claimed in any preceding claim including compressible annular seals surrounding the outer circumferential surface of the end of each tube and means for maintaining the seals in a compressed state.

10. A recuperator as claimed in Claim 9 in which recesses are provided in the sides of the holes in the block which co-operate with and engage means for maintaining the seals in a compressible state.

11. A recuperator as claimed in any preceding claim including projecting means formed as part of each block and extending into the holes in the block for centrally locating the tubes within the holes.

12. A recuperator as claimed in Claim 1 and substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG. 1.

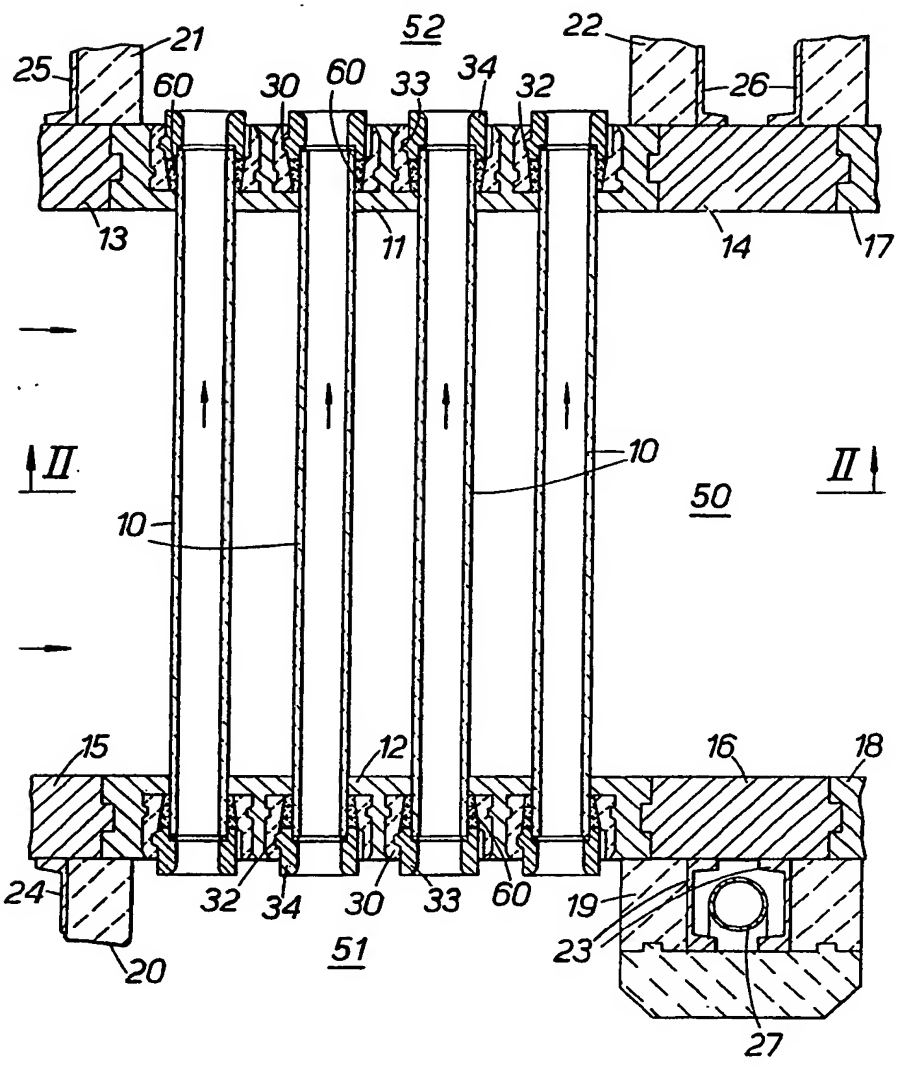

FIG. 2.